REGULATED DASHPOT WITH SHOCK-ABSORPTION FORCE CONTROLS

The present invention concerns a regulated dashpot with shock-absorption force controls, especially intended for motor vehicles, as recited in the preamble to Claim 1.

Regulated hydraulic dashpots with flow-regulating system that shift back and forth between compression and decompression phases in operation are known. Dashpots of this genus are described in German 3 803 838 C2 for instance.

There is a drawback to such dashpots in that their design permits them to shift only suddenly between the hard and soft phases, limiting the range of control. The comfortability of the ride can be increased only to a limited extent.

The object of the present invention is accordingly a dashpot of the aforesaid genus that can shift continuously between the hard and soft phases, whereby the valve-adjustment intervals can be varied at intervals that are not unnecessarily short or even unattainable.

This object is attained by the characteristics recited in Claim 1. Advantageous and advanced embodiments are addressed in Claims 2 through 8.

The present invention has many advantages. A continuous transition between hard and soft phases can be obtained by simple

means. Valve-adjustment intervals can be maintained long enough to allow the device to be manufactured at justifiable component costs and to be operated at low requisite adjustment powers.

One particular advantage is that the flow-regulating system can be modular and employed in different vehicles with various shock-absorption performances. Since there will be no sudden jolts when shifting between the hard and soft phases and vice versa, riding comfort will be considerably improved.

Various embodiments of the present invention will now be specified by way of example with reference to the accompanying drawing, wherein

Figure 1 is a schematic illustrating how a dashpot can be regulated in accordance with a single-chamber principle,

Figures 2 through 11 are schematics illustrating various other approaches to regulation in accordance with the single-chamber principle,

Figures 12 and 13 are schematics illustrating how a dashpot can be regulated in accordance with a resilient-chamber principle and with a two-chamber principle, and Figure 14 is a schematic illustrating regulation inside a dashpot cylinder.

The figures illustrate hydraulic circuitry specific to various dashpots. Each dashpot includes a piston 3 mounted on the end of a piston rod 2 and traveling back and forth inside a cylinder 1. A reservoir 4 contains a compressed gas that compensates for the volume of hydraulic fluid displaced by piston 3. Reservoir 4 can be integrated into the dashpot.

Figure 1 illustrates the hydraulic circuitry for a dashpot in accordance with the present invention. The dashpot includes two hydraulically parallel regulating valves 5 and 6. Hydraulically paralleling both regulating valves 5 and 6 is a very narrowly constricted bypass valve 7, which can alternatively be integrated into one or both regulating valves. Bypass valve 7 provides a minimal passage for the hydraulic fluid and accordingly prevents the dashpot from being entirely blocked while regulating valves 5 and 6 are closed. When closed, regulating valves 5 and 6 provide continuous regulation of the two phases and, when closed, allow the fluid to flow. Regulating valve 5 regulates the flow while piston 3 is traveling in the compression direction and regulating valve 6 regulates it while the piston is traveling in the decompression direction. The rate of flow depends on the one hand on the difference between the pressure in an upper chamber 8 and that in a lower chamber 9, the two chambers being separated by piston 3, and on the other hand on the cross-section of the passage through regulating valves 5 and 6 as dictated by flow controls like those known from German Patent 10 040 518.

Figure 2 illustrates another embodiment of the circuitry illustrated in Figure 1. In this embodiment, fluid can flow through both regulating valves 5 and 6 from either end as long as they are open, and the operative direction is prescribed by external checkvalves 10 and 11.

Figure 3 illustrates an advanced version of the circuitry illustrated in Figure 2. It employs spring-loaded checkvalves 12 and 13 instead of the external checkvalves 10 and 11. Such checkvalves will open to an extent that depends on the difference in pressure between chambers 8 and 9. The type of springs employed determine the intended performance curve of the dashpot in both compression and the decompression phases.

Figure 4 illustrates an advanced version of the circuitry illustrated in Figure 3. It includes a valve assembly 18 comprising unregulated spring-loaded checkvalves 16 and 17 that parallel regulated spring-loaded checkvalves 12 and 13. Checkvalves 16 and 17 parallel each other hydraulically and operate independently in both the compression and the decompression phases. Valve assembly 18 can be integrated into piston 3 and acts as a standard spring loaded piston. The performance curve for valve assembly 18 is set to "hard" and that of regulated spring-loaded checkvalves 12 and 13 to "soft". Regulating valves 5 and 6 can accordingly now switch independently of each other and continuously back and forth between hard and soft in both the compression and the

decompression phases. In addition to bypass valve 7, bypass valves 19 and 20 can be introduced paralleling spring-loaded checkvalves 12 and 13.

This embodiment ensures constantly reliable driving performance even when the electricity or electronics fail. In such an event, regulating valves 5 and 6 will substantially close, and continued operation of the dashpot will be ensured by the mechanical action of the spring-loaded checkvalves 16 and 17 in valve assembly 18 at a hard performance curve, preferably within piston 3, that is.

The embodiment illustrated in Figure 5 lacks the regulated spring-loaded checkvalves 12 and 13 employed in the embodiment illustrated in Figure 4. This embodiment is an advanced version of the regulable dashpot illustrated in Figure 1, employing a parallel valve assembly 18 like that in the version illustrated in Figure 4. The bypass valve can also be eliminated.

Figure 6 illustrates an alternative to the embodiment illustrated in Figure 5. Paralleling a valve assembly 18 that comprises unregulated spring-loaded checkvalves 16 and 17 with their hard performance curve are two similar spring-loaded checkvalves 12 and 13 with a soft performance curve. Checkvalves 12 and 13 can be brought into play by way of associated hydraulic switches 21 and 22, allowing a soft performance curve to be introduced while piston 3 is traveling in either the compression or the decompression direction. Paralleling these are two parallel one-

way checkvalves 23 and 24 with a soft performance curve that can be actuated and regulated by a regulating valve 25. This circuitry again allows the shock-absorption performance curves to be established anywhere between hard and soft independently of each other as desired with the piston traveling in either direction.

Circuitry similar to that illustrated in Figure 6 can be attained as illustrated in Figure 7. The soft checkvalves 12 and 13 in this embodiment are provided with a two-to-three way valve 26 instead of two individual switching valves.

Figure 8 illustrates another alternative embodiment. A valve assembly 27 comprises two spring-loaded checkvalves 28 and 29, each permitting the flow in a direction opposite that of the other. Checkvalves 28 and 29 have a soft performance curve and are alternately controlled by a two-to-three way valve 30. A flow-regulating valve 31 continuously opens or closes a parallel hydraulics line 32. A constricted bypass valve 33 ensures minimal unimpeded flow.

Figure 9 illustrates an advanced version of the of the embodiment illustrated in Figure 8. Upstream of flow-regulating valve 31 is a valve assembly 34 comprising two spring-loaded opposed-flow checkvalves 35 and 36. Checkvalves 35 and 36 also have a soft performance curve, although this curve can be varied between hard and soft. Bypass valve 33, which, like the one illustrated in

Figure 8, can parallel flow-regulating valve 31, two-to-three way valve 30, and/or the two series comprising a regulation-and-switching valve and checkvalves 35 and 36 or checkvalves 28 and 29, again ensures minimal flow as long as two-to-three way valve 30 and flow-regulating valve 31 are closed.

Figure 10 also illustrates an advanced version of the embodiment illustrated in Figure 8. This version includes, paralleling the components illustrated in Figure 8, another, unregulable, valve assembly 37 comprising spring-loaded opposed-flow checkvalves 38 and 39. Checkvalves 38 and 39 have a hard performance curve and can preferably be integrated into the piston in the form of standard cupspring-loaded valves.

Figure 11 illustrates another advanced version of the embodiment illustrated in Figure 8. It includes a valve assembly 27 comprising spring-loaded opposed flow checkvalves 28 and 29 with a soft performance curve, their direction of flow being reversed by a two-to-three way valve 30. The flow-regulating valve 31 in this embodiment, however, parallels valve 30, constantly maintaining the valve assembly 27 comprising checkvalves 28 and 29 in series with the latter. This embodiment also includes a constricted bypass valve 33 that ensures minimal flow.

The flow-regulating assembly 40 represented by the dot-and-dash lines in Figures 1 through 11 is depicted in the form of a preferably self-contained block 41 in Figures 12 and 13. Flow-regulating block 41 can also communicate with valve assembly 18, 27, 34, or 37.

The flow-regulating block 41 represented in Figure 12 is hydraulically interposed between lower cylinder chamber 9 and pressure-compensating gas reservoir 4.

Figure 13 illustrates a double-cylinder dashpot with a valve assembly 42 comprising two spring-loaded checkvalves 43 and 44 integrated into its piston 3. A bottom valve 46 in the form of a spring-loaded one-way valve is interposed between lower cylinder chamber 9 and a pressure-compensating reservoir represented by the space 45 between the cylinder's walls. The flow regulating assembly is preferably again in the form of a self-contained block 41 located outside the dashpot and hydraulically interposed between cylinder chambers 8 and 9.

The hydraulic switching-and-regulating components in the embodiment illustrated in Figure 14 are integrated, like the components illustrated in Figure 11, into the dashpot's piston 3.

List of parts

1. cylinder
2. piston rod
3. piston
4. reservoir
5. regulating valve
6. regulating valve
7. constricted bypass valve
8. upper cylinder chamber
9. lower cylinder chamber
10. checkvalve
11. checkvalve
12. checkvalve
13. checkvalve
14. compression spring
15. compression spring
16. checkvalve
17. checkvalve
18. valve assembly
19. constricted bypass
20. constricted bypass
21. hydraulic switch
22. hydraulic switch
23. checkvalve
24. checkvalve

25. flow-regulating valve
26. two-to-three way valve
27. valve assembly
28. checkvalve
29. checkvalve
30. two-to-three way valve
31. flow-regulating valve
32. hydraulics line
33. constricted bypass valve
34. valve assembly
35. checkvalve
36. checkvalve
37. valve assembly
38. checkvalve
39. checkvalve
40. flow-regulating assembly
41. flow-regulating block
42. valve assembly
43. checkvalve
44. checkvalve
45. intermural space
46. bottom valve